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Procedia Social and Behavioral Sciences 2 (2010) 7371–7376

Procedia
Social and Behavioral Sciences

Selected Papers of Beijing Forum 2004

Economics and Cognitive Science

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Cognitive science is potentially of great relevance to economics not just insofar as it tries to explain how human beings learn and meld beliefs with preferences to reach decisions and hence the choices that underlie economic theory, but also how and why they develop theories in the face of pure uncertainty, what makes those theories spread amongst a population or die out, and why humans believe in them and act upon them. In this essay I explore these issues in the expectation that cognitive science may give us some definitive answers that can serve as major breakthroughs in economics and the social sciences generally.

Economic theory is built on assumptions about human behavior-assumptions which are embodied in rational choice theory. Underlying those assumptions are implicit notions about how the mind works. Until recently economists have not self-consciously examined those implicit notions but recent work in economics and particularly game theory has forced economists to explore the sources of the beliefs that underlie economic choices and therefore to build a bridge between cognitive science and economics. In this essay I explore the path of economic reasoning that leads to cognitive science.

I

The neo-classical approach to analyzing the performance of an economy assumes that in the face of pervasive scarcity individuals make choices reflecting a set of desires, wants or preferences. Neo-classical theory is constructed by aggregating those preferences in the context of fixed resources, private goods, and given technology. The result has been a powerful set of tools to analyze resource allocation at a moment of time in developed economies under the assumption that the markets being modeled are governed by impersonal forces of supply and demand. The competitive model of neo-classical theory enshrined in general equilibrium theory makes a major contribution to economic understanding by demonstrating that a decentralized system of market forces would generate an efficient system of resource allocation. In this framework beliefs played no role in decision making.

But valuable as the neo-classical approach has been for the development of an elegant body of theory, it is a very imperfect tool for solving economic problems either at a moment of time or particularly over time. Both information and the enforcement of agreements are imperfect, leading to transaction costs. Further markets are the creature of political forces. In the real world of imperfectly competitive markets, beliefs determine the choices of the actors. Their motivation is derived from their private information and expectations about price movements. Moreover since some goods and services are public not only the traditional ones of national defense and public security, but in particular property rights and the rule of law—they are traditionally created through the political system, which entails not only knowledge about the preferences for such goods but the incentives to produce them, given peoples beliefs about others' willingness to pay for them. Preference based models of either markets or elections are relatively simple. Beliefs, on the other hand, are anything but simple because they involve some description of how people learn, how they update theories, and how they model the world they live in. And it is modeling beliefs that is at the heart of all theorizing in the social sciences.

Let us begin exploring the implications of the economist's approach by modeling situations in which the actor is conceived to maximize rewards subject to a complex consistent ordering of preferences. This is the economist's

doi:10.1016/j.sbspro.2010.05.099

substantive rationality assumption. It works well in competitive posted-price markets. The chooser need only choose the quantity to buy or sell because the competitive environment so structures the situation that price can effectively be viewed as a parameter and only the quantity need be chosen. If all choices were simple, made frequently with substantial and rapid feedback, and involved substantial motivation, then substantive rationality would suffice for all purposes. It would be both a predictive and a descriptive model of equilibrium settings, and learning models based upon it could be used to describe the dynamics out of equilibrium. But as soon as we move away from simple competition and the price depends on the behavior of other buyers and sellers, the complexity of the decision increases. Indeed, the interesting issues that require resolution come from the interaction of human beings in economic, political, and social markets. Knowledge of other people's actions and beliefs is an essential prerequisite to constructing useful models. But so too is a knowledge of their preferences because it is some melding of preferences and beliefs that determines choices. The strategic interaction of human beings is the subject of game theory and the vast literature on the subject that has evolved is a testimonial to its current appeal in the social sciences. But the current status of game theory itself makes clear that what has been missing in most game theoretic models is "a description of the players' reasoning processes and capacities as well as a specification of their knowledge of the game situation " (Bicchieri, 1993, p.127).

But the puzzle I seek to unravel is still deeper than how people reason and learn. It is how do humans evolve and believe in theories in the face of uncertainty. Let me explain. Frank Knight (1921) made a fundamental distinction between risk and uncertainty. In the case of risk, probability distributions of outcomes could be derived with sufficient information and therefore choices could be made on the basis of that probability distribution (the basis of insurance). In the case of uncertainty, no such probability distribution is possible and in consequence, economists have held that it is impossible to develop a body of economic theory in such cases and economic reasoning will be of little value. But human beings do construct theories all the time in conditions of pure uncertainty and indeed act on them and sometimes die for them. It is the widespread existence of myths, taboos, prejudices, and simply half baked ideas that serve as the basis of decision making. Indeed most of the fundamental economic and political decisions that shape the direction of polities and economies are made in the face of uncertainty. You have only to open a newspaper and read the headlines to observe such decisions every day.

Cognitive science is potentially of great relevance to economics—not just insofar as it tries to explain how human beings learn and meld beliefs and preferences to reach decisions and hence the choices that underlie economic theory, but also how and why do they develop theories in the face of pure uncertainty, what makes those theories spread amongst a population or die out, and why do humans believe in them and act upon them? In this essay I explore these issues in the expectation that down the road cognitive science may give us some definitive answers that can serve as the basis for major breakthroughs in economics and social sciences generally. In section II I will complicate the neo-classical model with additional constraints that arise with imperfect information and uncertainty; section III will explore these issues over time; section IV will examine the nature of ideologies; and the final section will explore the challenges these issues pose for cognitive science.

II

Neo-classical theory assumes that preferences are stable and that choices are made within a framework of constraints. The constraints include those imposed by income and technology but not those imposed by the institutions of a society. The reason for their absence is that the chooser is assumed to have perfect information and therefore certainty about alternatives. Agents in such a setting know what is in their self□interest, act in their self-interest, and are able to perform the calculations necessary to discriminate amongst alternative decisions. In such a world institutions are unnecessary. Institutions exist to structure human interaction in a world of uncertainty, or, as Ronald Heiner put it in a article of fundamental importance, "The Origins of Predictable Behavior" (1983), they arise from the effort of individuals in the face of pervasive uncertainty to reduce that uncertainty by limiting the choices available to the players and thereby making behavior predictable. Without institutions there would be no order, no society, no economy, and no polity. Therefore the construction of an institutional framework has been an essential building block of civilization.

Once we recognize this fundamental role of institutions in reducing uncertainty we must restructure the theoretical framework we use in economics and the other social sciences. Institutions not only provide the incentive structure of a society at a moment of time and therefore constrain the choice set, but also they are the carriers of the

process of change. Therefore whether we are modeling economic performance at a moment of time or over time, institutions are central to the theoretical construct. But what are institutions and where do they come from?

Institutions are formal rules (constitutions, statute and common laws, regulations), informal constraints (conventions, norms of behavior, and self imposed codes of conduct), and their enforcement characteristics. Institutions reflect the beliefs of the players—or at least of those players able to shape the rules. Behind beliefs are language and the cultural heritage of the players—a subject of the next section of this essay. Before turning to iot, I wish to explore the way the institutional context influences choices. Let me return to the instance where the substantive rationality assumption works well. It works well because the perfectly competitive market constrains the choices of the players. Or to put it directly, the rationality model works best when the institutional framework constrains the choice set and what passes for rationality is in good part a function of the institutional framework. Note carefully however that this framework, the scaffolding, will not necessarily produce efficient economic results. Indeed the scaffolding may so structure incentives that "rational" actors will make choices that produce inefficient economies. Indeed the sources of poor economic performance—as evidenced by poverty, low incomes, and stagnation—are a consequence of institutions that structure incentives that discourage productivity improving activities. Because institutions are a creation of the belief systems of those players who can shape the rules of the game, we must examine the way diverse belief systems emerge—which takes us to the role of time.

III

Time, in this context, is the dimension in which human learning occurs; the collective learning of a society (to use Hayek's term) embodies its past learning. We can briefly characterize this historical process as follows: Given the genetic architecture of the brain with its proclivities for language (Pinker,1994) and cooperative behavior (Barkow, Cosmides, and Tooby, 1995), tribal groups evolved very differently in different physical environments. They evolved diverse languages and, with different experiences, different mental models to explain the world around them. The language and mental models formed the informal constraints that defined the institutional framework of the tribe and were passed down intergenerationally as culture, taboos, and myths that provided cultural continuity. As specialization and division of labor developed, tribes evolved into polities and economies; the diversity of experience and learning produced increasingly different societies and civilizations with different degrees of success in solving the fundamental economic problem of scarcity. As the complexity of the environment increased human beings became increasingly interdependent and more complex institutional structures were essential to capture the potential gains from political and economic exchange.

Ever since Adam Smith economists have recognized that the wealth of nations is a function of specialization, division of labor, and the size of the market. But what economists have only lately come to realize is that as the market gets larger more and more resources must be devoted to transacting□that is to coordinating, integrating, and enforcing agreements. But there is more to the process of market expansion than simply increasing resources devoted to transacting. With small, personal exchange it pays to cooperate because the players interact repeatedly. But with impersonal exchange, to use the game theory analogy, it pays to defect. Historically it has been the creation of political and economic institutions that has altered the payoff to cooperation. But throughout most of history and still today in many societies the necessary institutions to produce cooperation—particularly the political ones—are not forthcoming. It entails a fundamental restructuring of a society to create a world of impersonal exchange. Because institutions reflect the belief system of a society, we must turn to the diverse cultural heritages of society to see why the collective learning has not been conducive to creating the necessary institutions. The learning process appears to be a function of (1) the way the existing belief system filters the information derived from experiences, and (2) the different experiences confronting individuals and societies at different times. In some cases the inital belief system has not been congenial to institutional innovations that would permit impersonal exchange; in other cases the experiences were not those that would incrementally alter the belief system to create such institutions.

An historical illustration can help to bring the issues into focus. Avner Greif (1994) has explored the contrasting cultural background of Genoese and Maghribi traders in the late medieval Mediteranean trade and the consequent different institutional frameworks they evolved to deal with the impersonal markets of long distance trade. The Genoese evolved bilateral enforcement mechanisms, which entailed the creation of formal legal and political organizations for monitoring and enforcing agreements, an institutional framework that lent itself to further

evolution of increasingly complex trade. The Maghribi, who had adopted the cultural and social attributes of Islamic society developed in-group social communications networks to enforce collective action. These networks, while effective in relatively small, homogeneous ethnic groups, did not lend themselves to the impersonal exchange that arises from the growing size of markets and diverse ethnic traders. Greif suggests the generality of these different belief systems for the Latin and Muslim worlds and then makes the connection between such belief structures in the European scene and the evolution of economic and political institutions.

The role of ideas and belief systems in shaping societies is not altogether new in the social sciences. Max Weber's celebrated The Protestant Ethic and the Spirit of Capitalism (1958) argued that Protestantism was the underlying source of capitalism. While his argument was flawed—it was broadly the Judeo-Christian tradition rather than Protestantism that was the source and he failed to make the connection between beliefs and the consequent institutions—he at least recognized that ideas matter. Modern economic theory has no role for ideas. Preferences are assumed to be fixed and, as noted above, beliefs played no role in decision making. It is only very gradually that economists are coming to realize that they must model beliefs and the way they evolve if they are to make further progress in the discipline. What still requires explanation is the diversity of belief systems and their cognitive basis.

IV

The pervasive human attempt to reduce uncertainty is the key to understanding the way humans process information and evolve belief systems. In order to make uncertain situations "comprehensible" humans will develop explanations. The pervasiveness of myths, taboos, and particularly religions throughout history (and prehistory, as well) suggests that humans have always felt a need to explain the unexplainable and indeed it is probably an evolutionarily superior trait to have any explanation rather than no explanation.

Merlin Donald (1991) maintains that there have been two stages in the cultural development of human thought—the mythic and the theoretic. The former, which characterized thought before Greeks evolved the process of thought and argument, was characterized by the use of external formalism and was employed in the service of myths and narratives. It is clear that this earlier form of thought continues to play a critical role in the formation of ideologies. Indeed the cultural heritage of a society provides the means to reduce the divergence of perceptions that will arise from diverse experiences and constitutes the means for the intergenerational transfer of unifying perceptions. Cultural learning not only encapsulates the learning from past experiences but also provides shared explanations for phenomena outside the immediate experiences of the members of the society in the form of myths, taboos, and dogmas.

Ideologies are organized belief systems, frequently having their origins in religions which make both proscriptive and prescriptive demands on human behavior. They incorporate views about how the "world works" and how it should work. As such they provide a ready guide to making choices. But I do not wish to confine myself to organized ideologies like communism. The ideological stereotypes that dominate choice-making in political and other contexts—such as conservative and liberal—are "looser" constructs that guide choices in the face of uncertainty just as surely as do more organized structures. But whether organized or "loose," ideologies play a complementary role to institutions in making behavior predictable. While institutions structure the external environment between human beings, ideologies structure the mental environment, thereby making predictable the choices of individuals over the range of issues relevant to the ideology. But what makes individuals susceptible to having their mental environment structured?

V

Let me pull together the threads of this discussion in order to point up the contributions that cognitive science can make to economics. The quest for order leads humans to construct elaborate forms of social, political, and economic beliefs which then inform their collective problem-solving behavior. Such scaffolds consist of both the mental models they possess—ie belief systems—and the external environment—ie institutions. Part of the scaffolding is an evolutionary consequence of successful mutations and is therefore a part of the genetic architecture of humans; part is a consequence of cultural evolution. Just what the mix is between the genetic architecture and the cultural heritage is in dispute. Evolutionary psychologists—psychologists who have donned the mantle of

sociobiology—have stressed the genetic architecture in the scaffolding process at the expense of the role of the cultural heritage.

Recent research by experimental economists lends some support to the evolutionary psychologists' position. In a recent paper by Elizabeth Hoffman, Kevin McCabe, and Vernon Smith summarizing a large number of experimental game results, they report:

"...people invoke reward/punishment strategies in a wide variety of small group interactive contexts. These strategies are generally inconsistent with, but more profitable than, the noncooperative strategies predicted by game theory. There is, however, consistency with the game theoretic folk theorem which asserts that repetition favors cooperation, although we observe a substantial use of reward/punishment strategies and some achievement of cooperative outcomes even in single play games.

Non Cooperative outcomes are favored, however, where it is very costly to coordinate a cooperative outcome, in larger groups, and even in smaller groups under private information. In large groups interacting through markets using property rights and a medium of exchange, and with dispersed private information, non cooperative interaction supports the achievement of socially desirable outcomes. Experimental studies have long supported this fundamental theorem of markets. This theorem does not generally fail, however, in small group interactions because people modify their strict self-interest behavior, using reward/punishment strategies that enable some approximation of surplus maximizing outcomes. Seen in the light of evolutionary psychology, such behavior is not a puzzle, but a natural product of our mental evolution and social adaptation." (1995)

Others such as Stephen J. Gould have suggested that there is a lot of slack in the genetic architecture which gives greater scope to cultural evolution. Gould has maintained not only that the selection environment changes but that in many cases it is relatively "loose," resulting in survival in which chance and breeding capabilities rather than competitive pressures may play a major role. Certainly many of our personal preferences— hunger, thirst, sex and perhaps some of our beliefs are genetically determined—but some preferences and most beliefs surely must be acquired.

Ken Binmore, a leading game theorist, maintains that our genes probably do not insist that we prefer or believe certain things but they are responsible for organizing our cognitive processes in terms of preferences and beliefs. He maintains that we come equipped with algorithms that not only interpret the behavioral patterns we observe in ourselves and others in terms of preference-belief systems but actively build such models into our own operating systems. The evolutionary advantage of such an inductive process is that new behaviors are tested against past experience in our internal laboratory. Humans enjoy the benefits of having the potential to learn a second best strategy in any game. Interactive learning is a two stage affair in which we first receive a social signal that tells us how to behave and then test the behavior against our preferences to see whether we wish to follow its recommendation.(1996)

One issue then is the extent to which the "mind is adapted" by several million years of genetic encoding versus the influence of cultural evolution; another although obviously related issue is just how the mind works. Both are central to answering the questions posed at the end of section I of this essay and we are far from settling them in either evolutionary psychology or in cognitive science.

The foregoing summary of research results in experimental economics makes clear that there is evidence of the innate drive for cooperation but the immense variation in the forms it takes and its varying degrees of success make the cultural component of cooperative behavior critical for the successful creation of impersonal political and economic markets. Creating cooperative frameworks of economic and political impersonal exchange is at the heart of problems of societal, political, and economic performance.

How does the mind work? It is easy to be impressed by the immense strides of cognitive science in recent years. It is also clear that there is immense disagreement among cognitive scientists. Is connectionism a promising research agenda? Far more mundane, what is the relationship between rationality and intelligence and is rationality deductive in nature, proceeding from the general to the specific? We are concerned to understand the way in which humans develop the fundamental equipment to put knowledge to work. There is an ongoing tension in the social sciences between evidence of human irrationality or limited rationality on the one hand and the substantive rastionality assumption of economists on the other hand. "On the one hand, there is a large body of research that documents striking failures of naive humans when confronting relatively simple tasks in probability theory, decision making, and elementary logic. On the other hand, there is the continuing belief of psychologists and computer scientists that by understanding human problem solving performance we will be better able to build machines that are truly

intelligent." (Lopes, 1991) Humans certainly reason, analyze, and deduce and in doing so construct categories, representations, and models; and where deductive reasoning is not possible humans reason by other, different means. The use of analogy and pattern recognition and transferring experience from other similar situations suggest the widespread use of inductive reasoning. However disagreements amongst cognitive scientists makes conjectures very tentative.

Curiously enough there are parallel sources of disagreement in economics and cognitive science. The rationality assumption in economics, in its pristine form, assumes that humans know what is in their self interest and make choices accordingly. The implication is not only that humans are perfectly informed about all possible alternatives but also that their choices are encumbered by the constraints imposed by technology and income (given fixed preferences) but unencumbered by the context within which humans make choices. In contrast, the new institutional economics argues that humans are typically making choices under conditions of uncertainty and those choices are constrained by the institutional context.

A similar dichotomy exists in cognitive science. The dominant tradition has regarded the mind as an information-processing machine akin to the computer. A contrasting—and minority—view is that a theory of cognition must come after, rather than before, a description of the cultural world in which human cognitive behavior is embedded. This position is elegantly argued in Edwin Hutchins, Cognition in the Wild (1995).

It should be apparent from the previous sections of this essay that I believe that the most promising approach to applying cognitive science to economics is one that assumes that humans have a quite different kind of intelligence than is implied by the rationality postulate and its deductive corollary. The integration of institutional analysis with a culturally conditioned approach to cognitive science seems to me to be the most promising approach.

A connectionist framework, which I find most congenial, suggests that most of learning comes from absorbing and adjusting to subtle events that have impact on our lives and which incrementally modify our behavior ever so slightly. Implicit knowledge evolves without ever being reasoned out. In fact we are relatively poor at reasoning compared to understanding and seeing the solution to problems. We are good at comprehending and understanding if the issue is sufficiently similar to other events that have happened in our experience. We are good at pattern matching and it is the key to the way we perceive, remember, and comprehend. This characteristic is the key to our ability to generalize and use analogy. Neural network learning constitutes fast but limited systems, which in effect substitute pattern recognition for reasoning. Pattern recognition provides just the right resources for motor control, face recognition, deciphering hand written zip codes, but leaves much to be desired in providing a framework to build careful, sequential reasoning. Nevertheless two factors have enabled humans to overcome this handicap:(1) scaffolding in which the genetic and cultural heritage has already done most of the reasoning and (2) representational redescription—the human capability to continually reorganize our knowledge via generalization and analogy to serve as the source of human creativity.

Here is the way a leading study on cognition characterizes the inductive process by which rule based mental models are formed and revised in an ongoing process: "The (cognitive) system is continually engaged in pursuing its goals, in the course of which problem elements are constantly being recategorized and predictions are constantly being generated. As part of this process, various triggering conditions initiate inductive changes in the systems rules. Unexpected outcomes provide problems that the system solves by creating new rules as hypotheses. Concepts with shared properties are activated, thus providing analogies for use in problem solving and rule generation...The major task of the system may be described as reducing uncertainty about the environment" (Holland et al, 1986, p.69).

But this ongoing inductive process by which rule-based models are formed must be put in the context of genetic encoding and the cultural scaffolding which imposes fundamental constraints on the choices of humans. Without drawing a neat division between the genetic and cultural components it is still a powerful implication of this approach that the domain of choices available is radically limited by the preexisting scaffolding as compared to rational choice models. But we have a long way to go to answer the two questions posed at the beginning of this essay: how human beings learn and meld beliefs and preferences to make the choices that underlie economic theory; and how and why they develop theories (and act on them) in the face of pure uncertainty.